

The NUCLEONICA Nuclear Science Portal

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Abstract. NUCLEONICA (www.nucleonica.net) is a new nuclear science web portal which provides a customisable, integrated environment and collaboration platform using the latest internet “Web 2.0” technology. NUCLEONICA is aimed at professionals, academics and students working in nuclear power, health physics and radiation protection, nuclear and radio-chemistry, and astrophysics. A unique feature of the portal is the wide range of user friendly web-based nuclear science applications. The portal is also ideal for education and training purposes and as a knowledge management platform to preserve nuclear knowledge built up over many decades.

Keywords: Nuclear science, internet portal, wiki, nuclear knowledge management, nuclear skills, education and training, networking, nuclear data, radioactive decay, dosimetry and shielding, gamma spectrometry, Monte Carlo, fuel cycle.

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INTRODUCTION

Due to a general lack of interest in nuclear power over many years, particularly in Europe, there has been a gradual decline in the nuclear skills base. The nuclear field has become very much a “grey-haired profession” with an ageing population of nuclear professionals. Today, as a result of recent developments on issues such as energy security, nuclear security and protection of the environment, we are witnessing a resurgence of interest in nuclear power. In order to support this development we will need a nuclear skills renaissance through education and training. There is also large range of “non-power” applications of radioisotopes and radiation in a variety of diverse fields such as medicine (e.g. cancer therapy), agriculture (e.g. pest population control), food irradiation (e.g. to increase shelf-life) and in industry (e.g. tracers, radiography, gauging, radiation processing, etc.), where such nuclear skills are also required. To support this renaissance, we have developed a nuclear skills “toolbox” NUCLEONICA (see Fig. 1) to encompass the knowledge of generations of nuclear scientists (in the form of databases, software applications, etc.) and make this available in a modern, user-friendly way which is fast and accurate using the latest internet technology. In particular, NUCLEONICA consists of an integrated environment and collaboration platform through the internet (databases, software applications, training courses) providing a user friendly, fast and accurate nuclear science information source for experts and non-experts alike.



FIGURE 1. The NUCLEONICA nuclear science portal (www.nucleonica.net) showing the navigation panel, Nuclear News and Hot Topics.

Recently, the Council of the European Union issued a report¹ on knowledge management and the needs for skills in the nuclear field in which it:

- acknowledged that the existence of a knowledge base is indispensable for safety reasons and to make improvements to the whole nuclear power cycle.
- noted that owing to the age pyramid within the nuclear sector, numerous retirements are scheduled in the short term.
- pointed out therefore that there is a real risk of the loss of nuclear knowledge if no measures are taken.
- emphasised strongly that the preservation of skills in the nuclear field requires a general effort involving public and private players and in particular the nuclear industry.

Knowledge and learning have been the subject of study for centuries. However, since the early 1990s, the "knowledge economy" or "knowledge society" has gained increasing attention in management circles with many large organizations engaging in a range of

knowledge and learning activities. More recently, there has been a proliferation of knowledge and learning tools available on the internet². It is claimed that the use of Web 2.0 tools such as blogs, wikis, widgets, etc. "encourages horizontal collaboration and harnesses the power of collective intelligence to boost productivity, foster innovation and create enhanced value"³. In Sept. 2008, IBM established its Center for Social Software in the US with IBM staff working alongside academics from MIT and Harvard to explore the impact of social networking on the workplace. In addition, through the use features such as "widgets", organisations can make data contained in "back end systems" available to users over the internet. At ITU, for example, we are currently developing a widget web-service which delivers small sections of the Karlsruhe Nuclide Chart⁴ to the user as a high quality graphic for use, for example in scientific publications.

NUCLEONICA's "LEARNING CENTRES"

The NUCLEONICA portal consists of four main "Learning Centres" (Fig. 2) for nuclear data, applications, knowledge, and networking. These are described briefly.

The screenshot displays the NUCLEONICA web portal with a dark blue header containing the logo and the tagline "... web driven nuclear science". Below the header is a navigation bar with links for Applications, My Preferences, and Help. The main content area is divided into several sections:

- Nuclide Explorer:** Features a 3D visualization of a nuclide chart with a color gradient from blue to yellow. Below the chart is a link to "Actual Chart: Standard".
- Search Nucleonica Documentation:** Includes a search bar and a "Search" button.
- Nuclear Data Retrieval:** A link to access nuclear data.
- nucleonica [wiki]:** A link to the NUCLEONICA wiki.
- Application Centre:** A list of application tools including Mass Activity Calculator, Decay Engine, Dosimetry & Shielding, Range & Stopping Power, webKORIGEN, Universal Nuclide Chart, Transport & Packaging, Nuclide mixtures, Nucleonica Scripting, Library creation for 3rd party software, Radiological Dispersion Module, Gamma Spectrum Generator (IE only), easy Monte Carlo (IE only), and Extended Graph Module.
- Data Centre:** A list of data resources including Physical Constants, Nuclide Datasheets, Nuclide Derived Data, Average Cross Sections, Radiations, Prompt Gamma, and Fission Yields.
- Knowledge Centre:** A list of knowledge resources including Nuclear News, Reading room, Useful Weblinks, Ask An Expert, and Element Information.
- User Profile (Welcome, Joe):** A sidebar on the right containing links for Edit Preferences, Administration, and MyCommunity Portal. It also lists "My Last Nuclides" (95 Am242 m, 95 Am242 n, 95 Am242, 93 Np239, 93 Np238), "My Nuclide Mixtures" (Natural Uranium, Np237 1g @ 1y, Cs137 + Ba137m, U232+Co60, Transuranics in 1 ton Spent Fuel), "My Sources" (Pu239 1 g, natu), "My Messages" (No messages for you at the moment), and "User Alerts" (No alerts at the moment).

FIGURE 2. NUCLEONICA's data, applications, and knowledge "Learning Centres". Also shown are the last nuclide and nuclide mixtures, and sources used.

Data Centre

Nuclear data can be accessed through online interactive nuclide charts⁵ (based on decay modes, half-lives, binding energy, spin, parity, etc.), reference data (datasheets, derived data, cross sections, spectral data, fission yields, etc.) and searchable databases for internationally evaluated nuclear data. The NUCLEONICA database⁶, which is based on the Joint Evaluated Fission and Fusion (JEFF3.1) radioactive decay datafile⁷, contains decay data on 3896 nuclides in ground and isomeric states. In addition, spectral data with a total of approximately 54000 energies and emission probabilities is available. Additional databases include the 8th Table of Isotopes⁸, prompt gamma neutron activation data, and effective dose coefficients.

Applications Centre

NUCLEONICA applications are designed to be user friendly, intuitive, and require a minimum of learning time. These powerful applications, which form the “backbone” of the nuclear science portal, can be used by professionals and students for everyday calculations. The applications include: the mass activity calculator, radioactive decay, gamma dosimetry & shielding⁹, fission yields, transport and packaging, library creation for spectroscopy, nuclide mixtures, and webGraphics. Recently added applications include a range and stopping power module¹⁰ for charged particle interaction with matter and a radiological dispersion module for collective dose estimates following a radiological dispersion event (restricted access)¹¹. Currently a new gamma spectrum simulator for a wide range of NaI and HPGe detectors is under development¹², together with a web-based Monte Carlo module for gamma and neutron dosimetry and shielding¹³.

Through a collaboration between the Karlsruhe Research Centre and the Institute for Transuranium Elements, a web-based version of KORIGEN called webKORIGEN¹⁴ has been developed for use in NUCLEONICA. For users, webKORIGEN overcomes the necessity of installation, input preparation and processing, compilation and debugging by offering an intuitive user-friendly web-based application – ideal for training purposes. With webKORIGEN, the user can concentrate on science rather than on the technicalities of large Fortran computer codes. WebKORIGEN supports calculations for a set of standardized problems, trimmed to three major classes of nuclear plants: the thermal power plants deployed worldwide as Pressurized Water Reactors (PWR) and Boiling Water Reactors (BWR) and a future extension to the current industrial technology the European Fast Reactor (EFR).

Knowledge Centre

The *Knowledge Centre*, or NUCLEONICA Wiki¹⁵, is the content management system (CMS) used for NUCLEONICA documentation. It is based on the same MediaWiki "engine" as used in Wikipedia. The NUCLEONICAwiki is used for online Help, ReadingRoom (for articles, and presentations), web-links, chemical element information, ask an expert Q & A etc.

The NUCLEONICAwiki is also used for training course organisation. To date, ten nuclear science training courses based on NUCLEONICA have taken place both at ITU and in external training centres. All training course announcements, agendas, full presentations, exercises, case studies, photo galleries etc., are available online in the NUCLEONICAwiki¹⁵.

Networking Centre

NUCLEONICA's networking features provide tools to encourage the development of discussion communities around the applications and to enhance collaboration with a view to "capturing" the tacit knowledge (knowledge management) from the expert developers and passing this on to a wider community. The Networking Centre allows users to stay in contact with colleagues from workshops or conferences, meet scientists from similar areas of interest and build up an international contact list. The users can represent themselves (personal page) and their Institute/Organisation in the international science community. The nuclear news aggregation service provides latest news and information on nuclear issues - the JRC's web crawlers scan more than one thousand newspapers every few minutes. NUCLEONICA's Calendar can be used to enter information on forthcoming events, meetings, conferences etc. The user can decide if he/she wishes to share this information with other users. In this way a user-generated calendar of events is created. Alternatively, the user can decide to keep the information in his personal diary.

NUCLEONICA: A PLATFORM FOR SCIENTIFIC APPLICATIONS DEVELOPMENT

NUCLEONICA application modules are designed to be very user friendly, intuitive, and require a minimum of learning time. With a few mouse clicks, users can obtain fast and accurate results almost instantaneously. In this mode of operation, normally only a single module can be used at any one time. Sometimes, however, the user would like to use the results from one module with another module. In some cases this can be done. For example, following a decay calculation, the parent and daughter nuclides can be stored as a "mixture". Thereafter, this mixture can be used for example in the gamma spectrum generator. In general, however, such batch processes require a more "hands on" approach. NUCLEONICA provides this with its scripting module¹⁵. Scripting refers to a programming task, in which pre-existing components or applications are connected to accomplish a new task. In accordance with this definition, the NUCLEONICA scripting gives the user a powerful programming interface through which he/she can access basic nuclear data and run all the NUCLEONICA applications. More information on the scripting language can be found in the NUCLEONICA wiki¹⁶. Also a detailed case study on targeted alpha therapy has been described which demonstrates powerful features of NUCLEONICA for modelling experiments through the use of batch scripts¹⁷.

One of the drawbacks of this approach is that the scripting module requires some programming experience. To minimise the amount of programming, we are currently investigating the use of web services to provide data feeds which can then be filtered and combined with other data feeds. Students, for example, with little knowledge of

programming should be able to combine modules with simple “drag and drop” operations. More advanced users should be able to go a step further and create new web services based on their applications.

An important problem, however, is to address the question of scientific application development support. How can the whole development process be efficiently organized in order to facilitate the development of new and upgrade of existing applications in Nucleonica? The development of web-based scientific applications in Nucleonica, either from existing programs (legacy codes) or from scratch, requires a considerable amount of time. Currently this is done by NUCLEONICA’s developers. A medium term goal is to “open up” NUCLEONICA to external developers by providing:

- a checklist of tools required
- access to the NUCLEONICA databases
- a testing environment where the developer and the NUCLEONICA team can test new application
- an upload facility whereby the developer can upload the application to the NUCLEONICA platform

The approach we propose is to make NUCLEONICA functionality available for developers of scientific software. Here we plan to offer particular NUCLEONICA modules (Decay Engine, Dosimetry & Shielding, etc...) as web services.

SUMMARY

An overview of the European Commission nuclear science web portal NUCLEONICA (www.nucleonica.net) has been given. The portal is dedicated to education, training and knowledge management in the nuclear sciences. In addition to providing internationally evaluated nuclear data, a unique feature of the portal is the provision of web-based nuclear science applications. The NUCLEONICAwiki – the "textbook" behind NUCLEONICA – is a powerful content management system for education and training purposes. In addition to providing the underlying theory behind the applications, it also provides a step by step description on the use of the modules.

NUCLEONICA's networking features provide tools to encourage the development of discussion communities around the applications. The aim here is to enhance collaboration with a view to "capturing" the tacit knowledge (knowledge management) from the expert developers and passing this on to a wider community. Currently the platform is being extended to provide an environment for scientists to develop their application within the NUCLEONICA framework.

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